

# Defining String Theory

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Washington Taylor  
MIT

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APS/DPF meeting

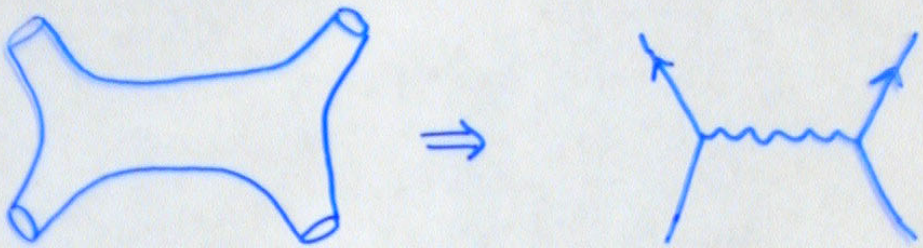
Philadelphia, PA

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W. Taylor (MIT)

## What is string theory?

Until recently,



set of rules for perturbation theory

Computes on-shell scattering of gauge quanta, gravitons

Perturbative expansion of quantum theory of gravity

- No nonperturbative formulation
- Space-time background fixed

## Nonperturbative formulations

Two nonperturbative descriptions of string/M-theory have emerged in last 5 years.

M(atrrix) theory:

M-theory in flat space-time

= supersymmetric matrix quantum mechanics

$$S = \text{Tr} \dot{X}_i^2 + [X_i, X_j]^2$$

AdS/CFT:

IIB string theory in  $\text{AdS}_5 \times S^5$

= 4D supersymmetric Yang-Mills theory

In both cases, geometry emerges in a nontrivial way

M(atrrix) theory: noncommutative matrix geometry

AdS/CFT: holography (scale/radius duality)

In M(atric) theory and AdS/CFT

asymptotic form of the space-time background is fixed

Can address local problems (*e.g.* black holes)

Cannot address global problems (cosmology)

To change asymptotic background:

must add  $\infty$  number of nonrenormalizable interactions

- Example: noncommutative field theory

$$\phi \star \psi = e^{i\theta^{ij} \partial_i \partial'_j} \phi(x) \psi(x')$$

Gives sensible nonlocal field theories

- Nonlocal field theories arise naturally from string theory
- How can we systematically treat such nonlocal theories?

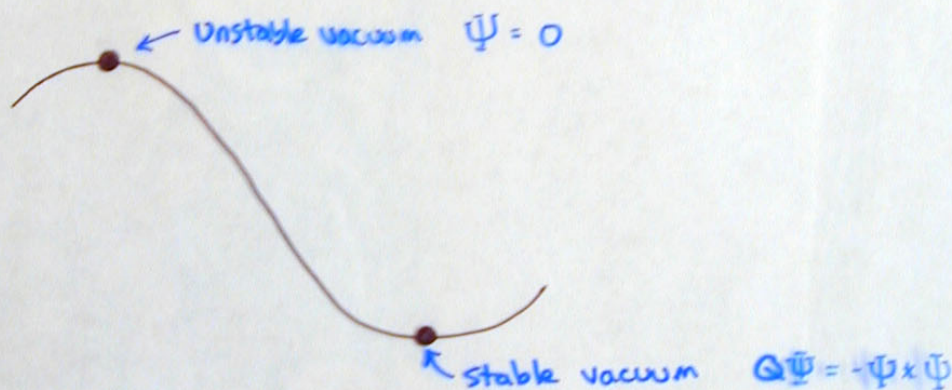
## Background-independent formulation?

String field theory has aspects of background independence

[SFT = nonlocal field theory in target space,  $\infty$  # fields]

In recent years, motivated by Sen conjectures:

Simplest (open bosonic) SFT has multiple vacua



Solution known only numerically, no analytic control

But:

Theory contains two geometrically and topologically distinct open string vacua, not connected by continuous (marginal) deformations

## Emergent geometry?

We need a similar story for closed strings

Framework is desired in which different space-time geometries/topologies arise from a single underlying theory

- Theory may have non-geometric definition
- Appropriate mathematics may not yet exist
- Difficult problem, but critical for string cosmology

Some approaches which go beyond classical geometry:

- Noncommutative geometry/noncommutative algebra
- Derived category program/K-theory
- String field theory

**None** of these approaches yet gives a complete background-independent dynamical theory.

## Geometry from closed strings in SFT?

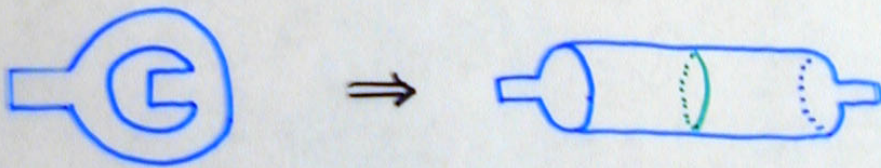
A promising approach: Attempt to replicate success of open string field theory for closed strings (geometry)

Closed string field theory?

- Existing formalism complicated, but possibly tractable

Closed strings in open string field theory?

- Closed strings appear in open string loops



- Quantum open string field theory may contain closed strings
- M(atric) theory, AdS/CFT as limits of closed/open SFT correspondence?
- Can we study closed string vacua (different space-time geometries) from this point of view?